Stream Plan

Goal to construct a natural stream channel that can develop free-form, self-sustaining conditions. This approach to stream restoration is based on the best and most current Rosgen-based scientific methods. This program was modified specific to stream restoration on reclaim areas of the Illinois Basin. These modifications were made by staff from the NCSU Stream Restoration Program in conjunction with Wetland Services.

Reference This process is derived from a scientific approach to natural channel design. All design parameters are based on optimum reference conditions throughout the region. Channel sizing is based on the watershed area of the stream. Channel area is derived from Regional curve data and sized for a 1-year return interval. Channel area is applied to a specific width/depth ratio. All other parameters are set, by ratio, to either Wbkf or Dbkf.

Engineers Note Channel sizing for SMCRA purposes is generally based on a return interval of 25-years. The channel volume illustrated in the attached drawings is scaled to a 1-year return interval. The flood prone area (Wfpa) is the channel that contains the SMCRA required 25-year event.

Instructions

1. **Alluvial Valley** It is necessary to construct a valley wide enough to accommodate the Wfpa. This emulates an alluvial valley naturally developed over geologic time. The lower gradients in alluvial valleys facilitate groundwater infiltration that drives intermittent stream conditions. The valley also provides a corridor for the stream to meander and develop free-form morphology. It is best to guide the direct backhaul process so as to minimize excavation.
   A. Valleys should be constructed of topsoil >4' deep, graded flat laterally (side to side), and with a downstream slope as flat as possible. 4' of topsoil is absolute minimum, and if the site has 20' of soil available, all 20' must be replaced on the surface. Unless contaminated, no soil should ever be buried.
   B. It is necessary to oversee backhaul to ensure that both ends of the valley tie in at grades preset by culverts or other existing features.
   C. No defined channel will be present at this point such that discharge during the early establishment period will be sheet flow (similar to a waterway). As such, it is important for the valley to be flat laterally. Otherwise preferential flow channels will develop and cause gullies.

2. **Early Establishment** The valley should then be seeded with appropriate annual erosion control species in mix with perennial stream and wetland grasses, herbs & shrubs. The valley should be allowed to vegetate, aggregate and stabilize. These areas need to sit thru a winter. Following early establishment, the valley will exist as a blank pallet into which the new stream may be constructed.

3. **Stockpiling** Topsoil, rock and coarse woody debris (trees & root wads) should be stockpiled during mining, and placed in logistic locations for use in stream construction. Toxic materials and non-target vegetation such as phragmites must be buried, and only clean soil used to restore the surface.

4. **Channel Construction** This step includes the construction of the basic channel. The basic channel has a set width and depth that increases as the stream moves down valley. It is recommended that construction be conducted such that a precise cut with minimal peripheral disturbance occurs.
   A. Once the stakes are set a hurricane ditcher can be used to make the initial cut to width/depth grade and side slope. Hurricane ditchers are tractor mounted PTO driven devices that can be set to a precise depth. These units can be easily navigated around staked corners to produce sinuosity. Finally, the cut material is discharged in a "rooster tail" manner that evenly distributes the cut material across the flood prone area without

restricting the streams floodplain access or causing damage to established vegetation. Next, an excavator is used to dig pools, construct riffles and place structure.

5. **Riffle Structures** serve the main function of grade control. As such, these features must be resistant to scouring during high velocity flows, and are key to preventing head cuts. The design and installation of riffle structures varies between B-channels and C-channels.
    A. **B-channel** riffle structures consist of a log(s) keyed across the channel. Refer to the drawing in Step 3 Riffle Construction B-channels.
    B. **C-channel** riffle structures consist of the appropriate sized material (fine gravel, coarse gravel, etc.) as determined by shear-stress calculations. Refer to the drawings in Step 3 Riffle Construction C-channels.
6. **Pool Construction** Pools are deeper than the riffle sections of the stream and serve the purpose of energy dissipation. Pools should be excavated to design specs located in Step 3 – Profile. Excess material should be disposed offsite or graded flat in a manner that will not restrict the streams floodplain access.
7. **Coarse Woody Debris** Install log vanes leading into meander bends & root wad revetments around the meander bends as detailed in Step 4.
8. **Planting and Erosion Control** These steps occur simultaneously. Be prepared, the 100-year event will likely occur the day after construction.
    A. Apply lime, fertilizer and seed to exposed stream banks.
    B. Apply appropriate erosion control (mulch, blankets, matting, etc)
    C. Install live stakes along riffles, runs and outside bends. Inside bends are depositional areas and require no live stakes, erosion control or planting.
    D. Plant the riparian zone in trees only after the stream has established good bank vegetation and is stabilized (1 to 2-years). Stream maintenance activities will damage riparian trees if planted too early.
11. **Monitoring Stations** Continual head cut monitoring is essential. A single headcut can unravel a new stream in one storm event. Establish monitoring stations according to criteria set forth in the Mitigation portion of this document.

Riparian Species			
Species	**Common Name**	**Strata**	**Indicator**
Carya glabra	Pignut Hickory	T	FACU
C. laciniosa	Shellbark Hickory	T	FAC
C. Ovata	Shagbark hickory	T	FACU-
C. Illinoensis	Pecan	T	FACU
Quercus alba	White Oak	T	FACU-
Q. lyrata	Overcup Oak	T	OBL
Q. flacata	Southern Red Oak	T	FACU
Q. imbricaria	Shingle Oak	T	FAC+
Q. macrocarpa	Bur Oak	T	FAC-
Q. muhlenbergii	Chinkapin Oak	T	NI
Q. rubra	Northern Red Oak	T	FACU
Q. shumardii	Shumardi Oak	T	FAC+
Q. bicolor	Swamp White Oak	T	FACW+
Q. michauxii	Swamp Chestnut Oak	T	FACW
Q. imbricaria	Shingle Oak	T	FAC+
Q. shumardii	Shumardi Oak	T	FAC+
Q. palustris	Pin Oak	T	FACW
Q. pagoda	Cherrybark Oak	T	FACW
Q. macrocarpa	Bur Oak	T	FAC-*
Q. palustris	Pin Oak	T	FACW
Taxodium distichum	Bald Cypress	T	OBL
Cephalanthus occidentalis	Buttonbush	S	OBL
*strong likelihood that species is more tolerant to hydric conditions than indicated.			
1. Riparian areas will be planted in no lees than 6 of the above listed genus and/or species at a rate of 60 RPM trees/acre. RPM propagules will be healthy saplings in 3			

pots. The planting schedule will follow the "Walk-Away" sequence:
  A. **Seedbed Preparation –** anytime before September.
  B. **Groundcover Establishment –** September & October.
  C. **Tree Installation –** October thru December.
  D. **Mat Placement & Fertilizer –** thru May.
2. Sometimes containerized trees are not applicable or available. In such cases bare root seedlings will be planted at a rate of 450/acre.
3. Species will be planted according their tolerance to water depth. For example, OBL species will be planted in wetter areas than FACU species.

Alluvial Valley & Stream Bank Species				
Genus and/or Species	**Common Name**	**Propagule**	**Strata**	**Indicator**
Agrostic spp.	Bent Grass	S 6oz/ac	H	FACW
Alisma subcordatum	Am. Water Plantain	R 50/ac	H	OBL
Alnus sp.	Alder	LS 1/3ft^2	T/S	FAC-FACW
Alopercurus pratensis	Meadow Foxtail	S 6oz/ac	H	FACW
Arundinaria Gigantea	Giant Cane	R 50/ac	S	FAC+
Asclepias spp.	Milkweed	R 50/ac	H	OBL
Carex spp.	Sedge	S 1-12oz/ac	H	FACW-OBL
Cinna latifolia	Wood Reed	S 1-12oz/ac	H	FACW
Cornus sp.	Dogwood	LS 1/3ft^2	T/S	FAC-FACW
Commelina spp.	Dayflower	R 50/ac	H	FACW
Cyperus spp.	Flat Sedge	S 1-13oz/ac	H	FACW-OBL
Echinochloa spp.	Indian Millett	S 3lb/ac	H	FACW
Eleocharis spp.	Spike Rush	S 1/2-2oz/ac	H	OBL
Elymus virginicus	Virginia Wild Rye	S 2lb/ac	H	FACW-
Elymus riparius	Riverbank Wild Rye	S 2lb/ac	H	FACW
Glyceria spp.	Manna Grass	S ½-4oz/ac	H	OBL
Juncus spp.	Rush	S 4oz/ac	H	FACW-OBL
Leersia spp.	Cutgrass	S 1lb/ac	H	OBL
Panicum spp.	Switch, etc.	S 6oz/ac	H	FAC-FACW
Peltandra spp.	Arrow Arum	R 125/ac	H	OBL
Polyganum spp.	Smart Weed	R,S 125,5lb/ac	H	FACW-OBL
Scirpus spp.	Bull Rush	S 4oz/ac	H	FACW-OBL
Sparganium spp.	Burreed	S 8oz/ac	H	OBL
Salix spp.	Willow	LS	S	OBL
Tripsacum dactyloides	Eastern Gamma Grass	S 4lb/ac	H	FACW
LS=Live Stake; R=Rooted Propagule; S=Seed				

1. PEM areas will be planted in no less than 8 of the above listed Genus and/or Species.
2. Species will be planted according their tolerance to water depth. For example, Milkweed and Dayflower will planted in shallower water up to 3" or saturated soil, while Lotus and Lilly will be planted in deeper water up to 18".
3. Rooted propagules will be planted at a time of year so as to insure adequate hydrology for the duration of the growing season.
4. Seed will be planted prior to the installation of rooted propagule. Timing will be commensurate to the seed requirements based on scarification, cold-stratification or other germination-enhancing treatments. Most seed will be planted between March – June.
5. Salix will only be used in bioengineering immediately along the top of bank, not across the riparian area. Target locations for willow include run sections and outside meander bends.
6. River Cane (Arundinaria gigantea) may be planted so as to develop scattered "breaks" throughout the site. Cane breaks will be established mainly in areas of stream bank stabilization and will be planted as rhizomes.

Design Parameters: C-channel (meandering) 0-1.3% slope

Riffle cross-section:
Cross-sectional area: from regional curve regression equation, 43.474*A^0.5222, where A is the watershed area in square miles
Width/depth (W/D) ratio: 15
Channel side slope: 3:1
Bankfull (top) width: calculated from cross-sectional area and W/D ratio
Mean bankfull depth: calculated from cross-sectional area and W/D ratio
Maximum bankfull depth: calculated from channel width, side slope, and area
Bottom width: calculated from channel depth, side slope, and area

Pool cross-section:
Point bar slope: 6:1
Pool depth: 2X maximum riffle depth
Pool bottom width: same as riffle bottom width
Pool top width: calculated from bottom width, depth, side slope, and point bar slope

Longitudinal profile:
Riffle length: 2X bankfull width
Pool length: same as riffle length
Run length: half of riffle length
Glide length: half of riffle length
Depth at end of run: one-third of elevation change between riffle and pool depths
Depth at head of glide: two-thirds of elevation change between pool and riffle depths

Plan view:
Sinuosity: 1.3
Floodplain width: 10X bankfull width
Meander length: 9X bankfull width
Beltwidth: calculated from sinuosity, meander length, and bankfull width

Channel lining specifications:
Shear stress: product of channel slope, bankfull maximum depth, and weight of water (62.4 lbs/cubic foot)
Velocity: from Manning's equation, with Manning's n = 0.035
d100 particle size: estimated (in millimeters) from a Rosgen regression equation: 152.02*x^0.7355, where x equals the shear stress

Design Parameters B-channel (Step Pool) 1.3-3% slope

Riffle cross-section:
Cross-sectional area: from regional curve regression equation, 43.474*A^0.5222, where A is the watershed area in square miles
Width/depth (W/D) ratio: 15
Channel side slope: 3:1
Bankfull (top) width: calculated from cross-sectional area and W/D ratio
Mean bankfull depth: calculated from cross-sectional area and W/D ratio
Maximum bankfull depth: calculated from channel width, side slope, and area
Bottom width: calculated from channel depth, side slope, and area

Pool cross-section:
Channel side slope: 2:1
Pool depth: 2X maximum riffle depth
Pool top width: same as riffle top width
Pool bottom width: calculated from pool top width, side slope, and depth

Longitudinal profile:
Step height: 0.33 feet
Riffle length: calculated from channel slope and step height
Pool length: same as riffle length

Plan view:
Sinuosity: 1.1
Floodplain width: 10X bankfull width
Meander length: calculated from sinuosity, pool length, and riffle length
Beltwidth: calculated from sinuosity, meander length, and bankfull width

Channel lining specifications:
Shear stress: product of channel slope, bankfull maximum depth, and weight of water (62.4 lbs/cubic foot)
Velocity: from Manning's equation, with Manning's n = 0.035
d100 particle size: estimated (in millimeters) from a regression equation from Rosgen: 152.02*x^0.7355, where x equals the shear stress